Appendix B

Data and Methods Associated with the Municipal, Construction, and Post-Construction Programs

Appendix B-1

Municipal Cost Questions and Results from the NAFSMA Storm Water Phase II Survey

Exhibit B-1a
NAFSMA Storm Water Phase II Survey

National Association of Flood and Stormwater Management Agencies
1299 Pennsylvania Ave NW, Eighth Floor West ω Washington, DC 20004 ω Tel: (202) 218-4122 ω Fax: (202) 842-0621

NAFSMA Storm Water Phase II Survey

The first six of the following questions correspond directly to the six "minimum measures" required by the proposed January 9, 1998 stormwater phase II regulation (63 FR 1536-1643). Completing these questions will give you an overview of the requirements your jurisdiction will likely face upon adoption of the final rules, and will give you a preliminary assessment of whether you are already meeting most of the requirements or will have to initiate new, locally funded activities. The additional questions will enable NAFSMA to evaluate how to best serve you and other Phase II communities.

Please fax (202) 842-0621 or mail the survey to Bill Morrissey at NAFSMA's National Office by Monday, August 31, 1998

Best contact person in your local government for Phase II information

Name:____

Address:____

City/State/Zip____

Phone____________________ Fax____________________

Email____

1. Do you have a public education/outreach program that distributes educational materials to the community about the impacts of storm water discharges on water quality and the steps to be taken to reduce pollutants in stormwater? Y N

   If yes, which of the following are included in your program, and what is the approximate annual cost? (Circle all appropriate letters)

A. Limiting the use and runoff of lawn and garden chemicals $__________
B. Promotion of "adopt a stream" and similar programs $__________
C. Promotion of storm drain stenciling $__________
D. Education of commercial, industrial, and institutional entities on storm water pollution $__________
E. Targeting of diverse communities, such as minority, disadvantaged, and children $__________
F. Informing public employees, businesses and the general public of hazards associated with illegal discharges and improper disposal of waste $__________
G. Other______________________________ $__________

   Approximate total annual cost: $__________

2. Are you required by State law and/or local ordinance to notify and/or involve your citizens in projects or programs that may effect local rivers, streams, lakes, or other types of water bodies? Y N

   - Do you have citizens advisory board that would advise elected officials or staff on new public works or water quality programs or activities? Y N

3. Do you have a storm sewer map for your jurisdiction that shows the location of major pipes, outfalls? Y N

   - If no, do you have an estimate of the cost to prepare such a map? $__________
   - Are you familiar with how to acquire such a map? Y N
   - Do you have a map or other data source that identifies areas of concentrated activity likely to be a source of storm water pollution, such as hazardous waste facilities, waste transfer stations, and

municipal "industrial" facilities, such as vehicle maintenance operations, transportation facilities (Bus garages [indoor/outdoor], light rail, commuter van pools, etc).? Y N

- If no, do you have an estimate of the cost to prepare such information? $______________
- Do you have a program to detect and address illicit discharges, including illegal dumping, to your storm water system? Y N
- If yes, what is the approximate annual cost of this program? $______________

4. Do you have an erosion/sediment control program for construction activities involving one or more acres? Y N

- Do you regulate or impose sediment control requirements on construction activities, management of construction waste (including human) and debris at construction sites? Y N

Note: Such a program must use an ordinance or other regulatory mechanism that requires the control of erosion and sediment to the maximum extent practicable and allowable under State or Tribal law. The program must control other waste at the construction site that may adversely impact water quality, such as discarded building materials, concrete truck washout and sanitary waste. The program must include, at a minimum, requirements for construction site owners or operators to implement appropriate best management practices (BMP), provisions for pre-construction review of site management plans, procedures for receipt and consideration of information submitted by the public, regular inspections during construction, and penalties to insure compliance.

- If yes, what is the approximate annual cost of this program? $______________

5. Do you have a program to permanently address storm water runoff from new development and redevelopment projects that result in land disturbance of one or more acres? Y N

Note: Such a program must include a plan to implement site-appropriate and cost-effective structural and non-structural best management practices (BMP's), and ensure adequate long-term operation and maintenance of such BMP's. The program must ensure that controls are in place that would prevent or minimize water quality impacts. Examples of non-structural BMP's include policies and ordinances that result in protection of natural resources and prevention of runoff, such as growth limits, protection of wetlands and riparian areas, minimizing impervious areas, maintaining open space, and minimizing disturbance of soils and vegetation. Examples of structural BMP's include detention ponds, filtration practices such as grassed swales and sand filters, and infiltration practices such as porous pavement.

- If yes, what is the approximate annual cost of this program? $______________

6. Do you have a program to prevent or reduce pollutant runoff from municipal operations? Y N

Note: Such a program must include local government employee training to prevent and reduce storm water pollution from government operations, such as park and open space maintenance, fleet maintenance, transportation facilities, planning, building oversight, and storm water system maintenance.

- If yes, what is the approximate annual cost of this program? $______________

7. Are you aware that by August 7, 2001 municipalities less than 100,000 population that own or operate an "industrial facility are required to submit a NPDES permit application for storm water discharges? Y N

Note: Municipalities less than 100,000 were exempted by a provision in ISTEA in 1991 from having to permit facilities they own or operate with "storm water discharges associated with industrial activity" except for airports, power plants, and uncontrolled sanitary landfills. Regulations effective August 7, 1995 extended this exemption for six years. "Industrial" facilities that a small municipality might own or operate that are exempted until 8/7/2001 include: vehicle maintenance shops, asphalt and concrete batch plants, sand and gravel mines, municipal solid waste landfills or transfer stations, hazardous waste landfills and land-application sites, hazardous-waste recycling facilities, municipal wastewater treatment plants over 1 MGD, and municipal construction sites (including new road projects) over 5 acres.

- Are You aware that if You own or operate an airport, power plant, or uncontrolled sanitary landfill, you were required to submit a storm water permit apllication by October 1, 1994? Y N

Note: Uncontrolled sanitary landfills are active or closed landfills or open dumps that do not meet the runoff control requirements for solid waste facilities defined in RCRA.

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8. What is the area served by your storm water system, measured in square miles? ______________ square miles

   ♣ What is the area of your jurisdiction, if different from above? __________ square miles

9. What is the population of your jurisdiction? ______________

10. Is there an adjoining or overlapping city or county that already has a stormwater program permitted by the State or EPA that may agree to:

    a) operate a joint stormwater program for both your cities;
    b) operate selected parts of the program jointly for both your cities;
    c) provide you with assistance in developing and implementing your program:
    d) talk to you about the program;
    e) none of the above;
    f) don't know;

11. What portions of the storm water sewer system in your jurisdiction do you currently regulate, maintain, and replace when obsolete? **(Check all that apply)**

Portion of System	**Regulate**	**Maintain**	**Replace**
Jurisdiction owned properties	o	o	o
Jurisdiction maintained streets/roadways	o	o	o
Adopted easements on private property	o	o	o
All streams, ditches and storm drains that...	o	o	o

(check statement below that matches your defintion of storm drain)

___ serve more than one property
___ contain runoff from a public street or property
___have a drainage of_______ acres
___ other___________________________________

12. How are your current storm water system operations, maintenance, repair, rehabilitation, and replacement activities funded? (Circle all letters that apply)

A. Your city's/agency's general revenues _____ percent
B. A separate storm water system fee or tax _____ percent
C. A combined water utility fee or tax _____ percent
D. A dedicated street maintenance revenue _____ percent
E. A regional storm water management agency _____ percent
F. Other ______________________________ _____ percent

13. How do you expect to pay for this new program? **(Circle all letters that apply)**

G. Your city's/agency's general revenues _____ percent
H. A separate storm water system fee or tax _____ percent
I. A combined water utility fee or tax _____ percent
J. A dedicated street maintenance revenue _____ percent
K. A regional storm water management agency _____ percent
L. Other ______________________________ _____ percent

14. How do you expect to prepare the required permit application when the time comes?

A. Existing staff
B. Hire new permanent staff
C. Hire new temporary staff
D. Consultant
E. Do not know

15. Prior to receiving this package, were you notified that you would soon be required to have a stormwater pollution control program? Y N

If yes, what has been your primary source of information? (Circle all letters that apply)

A. National League of Cities
B. National Association of Counties
C. American Public Works Association
D. National Association of Flood and Stormwater Management Agencies
E. US Environmental Protection Agency
F. State
G. Magazines/publications
H. Other ______________________________

16. How can NAFSMA and other organizations best assist you in meeting Phase II storm water requirements?

A. Workshops and seminars on the regulations
B. Sharing activities of other jurisdictions
C. Written materials through the mail
D. Web page updates
E. Other ______________________________
F. Other ______________________________

Survey Completed By (If different than contact): ______________________________

For questions concerning the survey please contact Bill Morrissey in NAFSMA's Washington Office.

Phone: (202)218-4122 E-Mail: Morrisseyw@carmengrp.com

Please return the survey to Bill Morrissey via mail or either fax number:

Bill Morrissey
NAFSMA
1299 Pennsylvania Ave, Eighth Floor West
Washington, DC 20004

Fax: (202)842-0621 or (202)785-5277

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NAFSMA assigned an ID number to each city and county that responded to their survey. Of the 121 respondents, 56 were able to provide cost information about their storm water programs. Exhibit B-1b presents the cost information reported by the 56 respondents.

Exhibit B–1b. NAFSMA Raw Data Used in the Economic Analysis
Annual Costs Reported

ID#	Question 1 Public Ed/ Outreach ($)	Question 3 Illicit Discharges ($)	Question 4 Erosion/Sed Control ($)	Question 5 Development ($)	Question 6 Muni Runoff ($)	Question 9 Population ($)
1		5,000				4,900
2			40,000	40,000		40,000
4			30,000	30,000		30,000
5					2,000	45,000
6			5,000	5,000		12,500
8	27,500	50,000	35,000	20,000	15,000	23,500
11	600					4,406
13				25,000		23,500
14	2,000	2,000				150,000
15	30,000					30,000
20		5,000	5,000	5,000	2,500	10,000
22				100,000		15,000
25		100,000		100,000		50,600
27	2,000		4,000	5,000	2,000	3,300
28		100,000				100,000
31	3,000		10,000	7,500		88,000
33		30,000	20,000	10,000		37,000
35	3,000		40,000	50,000		13,000
36			1,040			23,000
37				40,000		65,000
40		35,000		10,000		45,000
41			5,000	5,000		29,800
44			10,000	10,000		72,000
46	400		500	1,200		15,396
47	50,000		7,000	3,000	7,000	120,000
50	114,000					50,000
52			75,000	75,000	500,000	25,000
55	1,000					33,000
56	10,000	6,000				68,000
58	1,000			5,000		100,000
60	200	10,000	15,000	5,000	5,000	35,000
63		5,000	2,000		3,500	4,200
64		75,000			10,000	33,000
65					300,000	90,000
66				30,000		80,000
67				150,000		118,000

Exhibit B–1b. NAFSMA Raw Data Used in the Economic Analysis
Annual Costs Reported

ID#	Question 1 Public Ed/ Outreach ($)	Question 3 Illicit Discharges ($)	Question 4 Erosion/Sed Control ($)	Question 5 Development ($)	Question 6 Muni Runoff ($)	Question 9 Population ($)
71			1,000			5,200
76	18,700	30,000	45,000	15,000	500	167,854
77	5,350		1,000			27,300
79			75,000	75,000		78,000
80			9,000	9,000		19,000
99		1,000	15,000	18,000	1,000	16,000
106	3,650	4,000	7,000	1,000		14,000
108				30,000		65,000
109		2,000	10,000	50,000	5,000	99,000
113	5,000	500	2,000	2,500	500	17,500
122			3,000	8,000	1,000	26,000
123	2,000		25,000			43,000
133	6,100	25,000	5,000	5,000	10,000	105,000
136	152,000	15,000	15,000		50,000	250,000
137			30,000	50,000	30,000	84,105
138			5,000	5,000	1,000	1,000
139				90,000	200,000	43,000
141			35,000			85,000
144	40		10,000	10,000		100,000
147			8,000			12,000
% Resp:	18%	16%	29%	30%	16%	

Exhibit B-1c.
Average and Percentile Costs for Five Phase II Minimum Control Measures
(Per Household Costs, $1998)

	Public Education/ Outreach	Illicit Discharges	Erosion/ Sediment Control	Development	Municipal Runoff[1]	Totals: All Categories
Mean Cost	$0.91	$1.78	$1.84	$2.64	$1.75	$8.93
Minimum	$0	$0.03	$0.09	$0.07	$0.01	$0.19
25%	$0.08	$0.20	$0.30	$0.37	$0.14	$1.09
50%	$0.37	$0.75	$1.08	$1.24	$0.52	$3.96
75%	$1.01	$2.65	$2.10	$2.79	$1.63	$10.17
95%	$3.04	$5.61	$7.92	$10.68	$9.08	$36.34
Maximum	$5.97	$5.95	$13.10	$17.47	$12.19	$54.68

Source: NAFSMA Phase II Survey Raw Data Report, 1998
[1]These estimates removed the effect of one disproportionately huge "outlier" (almost 15 times the mean cost for all other municipalities and 4 times greater than the next highest per capita cost) in one municipality's (respondent number 52) estimate of its annual municipal runoff control costs.

Appendix B–2

Construction Start Methodology

Appendix B–2.
Construction Start Methodology

This appendix describes the methodology used to estimate the number of construction sites potentially incurring incremental costs of the Phase II Storm Water rule. In determining the universe of construction starts, a correlation was made between the information obtained from the fourteen municipalities on construction starts per disturbed area and data obtained from the national building permits. The methodology consisted of ten steps. The appendix discusses each step in detail. Note that the exhibits referenced in the text are presented at the end of the appendix.

Step One. EPA obtained data files from the United States Bureau of the Census indicating the number of building permits issued by each building permit-issuing authority in the United States. Data files were obtained for the years 1980–1995. The Census Bureau stopped collecting nonresidential building permit information in 1995, which precluded the use of 1995 data in this analysis.

The data files, covering 1980 to 1994, group the building permits into the following categories:

- Residential housekeeping buildings (single-family buildings, two-family buildings, three- and four-family buildings, and five or more family buildings, residential non-housekeeping buildings, nonresidential buildings)
- Residential non-housekeeping buildings (hotels, motels, tourist cabins, lodges, dormitories, rooming houses, and fraternity houses)
- Nonresidential buildings (amusement, social, and recreational buildings; churches and other religious buildings; industrial buildings; parking garages; service stations; hospitals; office, bank, and professional buildings; public works and utilities buildings; schools and other educational buildings; stores and customer services; jails and reformatories; and structures other than buildings, such as marinas, boat houses, dog pounds, boardwalks, and outdoor stadiums)
- Additions, alterations, and conversions of nonresidential and non-housekeeping residential buildings (excluding “installation” permits issued to cover electrical, plumbing, heating, and air-conditioning)
- Additions of residential garages and carports
- Demolition and razing of buildings.

Step Two. EPA summarized the data for building permits issued in 1994 in the 50 states, the District of Columbia, the Virgin Islands, and Puerto Rico.

Step Three. EPA removed building permit categories with a 400 and 600 series designation. The building permits issued for Category 400 include additions, alterations, and conversions to residential and nonresidential buildings, and additions of residential garages and carports. These structures typically disturb less than ½ acre of land or involve internal renovations. Category 600 includes the demolition and razing of buildings, which may not disturb land. If land-disturbing activities were to occur following demolition or razing, these activities should be included in the storm water permit application for the new construction activity.

Step Four. EPA selected 1994 as the base year for developing construction cost estimates because it was the year of most recent data on building permits issued in the United States. The cost analysis, however, used 1998 as its base year and the number of construction starts was escalated from 1994 to 1998 using an average annual growth rate of 1.3%, which reflects the average growth rate in permits during prior years.

Step Five. EPA grouped building permits into similar types of buildings and activities. The following equivalents were developed based on commonly used zoning code descriptions and the Census Bureau's definition of building categories:

- code 101 represents single-family detached homes;
- codes 103, 104, and 105 represent other "attached" homes (e.g., apartments, townhouses, condominiums);
- codes 213, 214, 318, 321, 322, 324, 327, and 328 represent commercial establishments;
- code 320 represents industrial or manufacturing facilities;
- codes 319, 323, 325, and 326 represent all institutional buildings (e.g., schools, hospitals, churches, government buildings);
- code 329 represents parks and recreational facilities.

Step Six. EPA converted building permits to storm water construction starts. A storm water construction start encompasses general construction activities occurring on a given site at a given time; it is independent of the number of building starts. For example, if a contractor builds 20 single-family homes on a four-acre parcel of land, that contractor will require 20 separate building permits. The same development would be considered one storm water construction start, assuming it is part of a common plan of development or sale. Municipalities do not ordinarily maintain construction records from a "storm water construction start" perspective. Therefore, to estimate the scope of this category, it is necessary to translate building permits into storm water construction starts.

In the EA for the proposed rule, construction data collected from Prince Georges County, Maryland was used to translate building permits to storm water construction starts nationwide. For this EA, EPA has supplemented that data with data from thirteen other local government jurisdictions from around the country to develop new ratios to estimate the number of construction starts.

Exhibit B–2–1 categorizes the construction type, the number of housing developments, the number of housing units constructed, and the number of commercial, industrial, institutional, and parks and recreational units constructed by size in acres. Exhibit B–2–1 also lists the number of units per development within the single family homes category. These data are required because the assumption that one building permit equals one storm water permit does not apply to single family homes. (The derived values based on this data are designated in the equation used in step seven below as SF_D with the relevant subscript. For example, $SF_{D½}$ equates to the average number of single-family homes built on developments disturbing between zero and ½ acre.)

Step Seven. EPA developed ratios to estimate the number of building permits issued by construction type (residential, commercial, industrial, etc.) for each size category. The size category is equivalent to the land area disturbed by an individual development. Exhibit B–2–2 indicates the percentages used to estimate the type of construction by size category. For example, Exhibit B–2–2 gives a percentage value of 1.39% for Residential Detached home sites on construction sites that disturb between 0 and ½ acre. This value was derived by dividing 252 (the number of units built within this size category, shown in Exhibit B–2–1) by 18,134 (the total number of units built for all size categories of residential detached homes, also in Exhibit B–2–1), and multiplying the result by 100. Exhibit B–2–2 shows that approximately 86% of the building permits issued for single-family homes were constructed in developments disturbing more than five acres of land.

The following example uses the methodology to convert the number of building permits into storm water permits, as outlined in Steps 6 and 7 for Alabama.

<u>Example:</u>

In 1994 the State of Alabama issued 14,459 single-family building permits, 558 multi-family building permits, 2,543 commercial building permits, 175 industrial building permits, 233 institutional building permits, and 775 parks and recreation building permits. The following equation was used to convert these numbers to construction starts:

$$N_4 = (SF_B \div SF_{D4} \times SF_{P4}) + (MF_B \times MF_{P4}) + (C_B \times C_{P4}) + (Ind_B \times Ind_{P4}) + (Inst_B \times Inst_{P4}) + (P\&R_B \times P\&R_{P4})$$

where

N_4	=	Number of construction starts between four and five acres in State X
SF_B	=	Number of building permits reported by the Census Bureau in State X for the construction of single-family detached homes.
SF_{D4}	=	Average number of single-family homes built on developments disturbing between four and five acres in the municipalities where data was collected (from Exhibit B–2–1).
SF_{P4}	=	Percent of single-family development plans disturbing between four and five acres of land in the municipalities visited, as compared to the total number of single-family development plans reviewed in the municipalities visited (from Exhibit B–2–2, converted to a decimal, e.g., 4.87% = 0.0487).
MF_B	=	Number of building permits reported by the Census Bureau in State X for multiple-family dwellings.

MF_{P4}	=	Percent of multi-family dwelling plans disturbing between four and five acres of land in the municipalities visited, as compared to the total number of multi-family dwelling plans reviewed in the municipalities visited (from Exhibit B–2–2, expressed in the formula as a decimal).
C_B	=	Number of building permits reported by the Census Bureau in State X for commercial establishments.
C_{P4}	=	Percent of commercial establishment plans reviewed in the municipalities visited disturbing between four and five acres of land, as compared to the total number of commercial establishment plans reviewed in the municipalities visited (from Exhibit B–2–2, converted to a decimal).
Ind_B	=	Number of building permits reported by the Census Bureau in State X for the construction of industrial establishments.
Ind_{P4}	=	Percent of industrial establishment plans reviewed in the municipalities visited disturbing between four and five acres of land, as compared to the total number of industrial establishment plans reviewed in the municipalities visited (from Exhibit B–2–2, converted to a decimal).
$Inst_B$	=	Number of building permits reported by the Census Bureau in State X for the construction of institutional establishments.
$Inst_{P4}$	=	Percent of institutional construction plans reviewed in the municipalities visited disturbing between four and five acres of land, as compared to the total number of institutional construction plans reviewed in the municipalities visited (from Exhibit B–2–2, converted to a decimal).
$P\&R_B$	=	Number of building permits reported by the Census Bureau in State X for the construction of parks and recreational facilities.
$P\&R_{P4}$	=	Percent of park and recreational facility plans reviewed in the municipalities visited disturbing between four and five acres of land, as compared to the total number of plans for parks and recreational facilities reviewed in the municipalities visited (from Exhibit B–2–2, converted to a decimal).

Using the Alabama data gives the following results:

$$N_4 = (14{,}459/(884/44) \times 0.0487) + (558 \times 0.10843) + (2{,}543 \times 0.0507) + (175 \times 0.0515) + (233 \times 0.0581) + (775 \times 0.0722)$$

$$N_4 = 35 + 61 + 129 + 9 + 14 + 56$$

$$N_4 = \underline{304}$$

This value is reported in Exhibit B–2–3 in the Alabama row under Construction Starts four to five Acres as 304 starts.

Step Eight. EPA collected and reviewed state erosion and sediment control regulations during January and February, 1997. Based on that review, EPA identified states that have erosion and sediment control requirements for sites that disturb between one and five acres (Phase II) that are equivalent to EPA's final Phase II rule requirements. In states that regulate construction starts that disturb between one and five acres, or a subset of that acreage range (Georgia, New Hampshire, West Virginia, and Wisconsin) those starts were eliminated from the analysis because they already have sediment and erosion control requirements similar to Phase II. The following states have equivalent programs:

- Connecticut (all starts)
- Delaware (all starts)
- District of Columbia (all starts)
- Georgia (two- to five-acre starts)
- Maryland (all starts)
- Michigan (all starts)
- New Hampshire (two- to five-acre starts)
- New Jersey (all starts)
- North Carolina (all starts)
- Pennsylvania (all starts)
- Puerto Rico
- South Carolina (all starts)
- West Virginia (three- to five-acre starts)
- Wisconsin (three- to five-acre starts)

Step Nine. The Coastal Nonpoint Pollution Control Program directs municipalities in the coastal zone to require erosion and sediment controls for construction starts disturbing less than 5 acres of land. Coastal municipalities are required to have construction erosion and sediment control requirements in place before issuing Phase II permits. EPA's cost estimate includes only those states and counties that do not have enforceable policies and mechanisms for erosion and sediment controls at construction starts. EPA eliminated construction starts located in CZARA states and counties (as identified by EPA *Coastal Nonpoint Finding Status*. April 22, 1998) where CZARA is, or is expected to be, used as the primary enforcement tool. As a result, all construction starts in the states of Florida, Rhode Island and the Virgin Islands as well as starts from CZARA counties in Alaska, Massachusetts, and Virginia were excluded.

Exhibit B–2–3 indicates the number of storm water construction starts by state and size category after all equivalent programs have been removed.

Step Ten. Finally, EPA chose to examine the Phase II construction universe, as presented in Exhibit B–2–3, by climatic zones. Climatic zones reflect regional variations in rainfall intensity and amount. This step involved estimating the percentage of land area within each state corresponding to a given climatic zone and then using these percentages to determine the number of starts within each zone. The results are presented in Exhibit B–2–4. The total number of construction starts between one and five acres is 123,145. This estimate was reduced by 15% to account for waivers, resulting in slightly more than 110,223 starts. This is the number of Phase II construction starts that is used throughout the cost analysis. To determine that 21.1% of all starts may be regulated by Phase II, EPA divided the number of Phase II construction starts by the total number of permits issued nationwide (110,000/522,000 = 21.1%).

Summary

This appendix identifies the methodology used to identify the number of construction starts potentially incurring incremental costs of the Phase II Storm Water rule. The Phase II construction universe comprises 110,000 construction sites ranging from one to five acres in size.

Exhibit B–2–1. Construction Starts by Acreage and Type from Selected Municipalities

Construction Acreage	Construction Type							Total Starts	Percent of Total
	Residential Detached Homes[1]		Residential Attached Developments[2]	Commercial[3]	Industrial[4]	Institutional[3,4]	Parks and Recreational		
	Number of Developments	Number of Units Built							
> 0 acre # ½ acres	194	252	23	101	22	38	15	393	14.94%
> ½ acres # 1 acre	72	150	20	165	17	42	5	321	12.21%
$1 acre # 2 acres	71	375	30	230	22	55	13	421	16.01%
> 2 acres # 3 acres	53	370	18	116	13	34	6	240	9.13%
> 3 acres # 4 acres	60	588	21	62	13	23	4	183	6.96%
> 4 acres # 5 acres	44	884	31	48	7	18	7	155	5.89%
> 5 acres # 10 acres	138	3,880	56	99	22	48	21	384	14.60%
> 10 acres	223	11,636	87	125	20	52	26	533	20.27%
Total	**855**	**18,134**	**286**	**946**	**136**	**310**	**97**	**2,630**	**100%**

Sources: Austin, Texas; Baltimore County, Maryland; Cary, North Carolina; Ft. Collins, Colorado; Lacey, Washington; Loudoun County, Virginia; New Britain, Connecticut; Olympia, Washington; Prince George County, Maryland; Raleigh, North Carolina; South Bend, Indiana; Tallahassee, Florida; Tucson, Arizona, and Waukesha, Wisconsin.

[1]*Residential detached* refers to the number of developments, by size category, and the total number of single-family homes constructed in those developments. Each home represents a building permit, but only the development requires a storm water permit.
[2]*Residential attached* refers to the number of developments, by size category, and the number of units built in those apartments, townhouses, and condominium complexes. Each development represents a single building permit.
[3]For the commercial, industrial, institutional, and parks and recreational categories, each unit represents both a building permit and development.
[4]Institutional includes medical, religious, educational, and governmental structures.
[5]The total column includes the number of units built in all cases except for residential attached, where the number of developments was used.

Exhibit B–2–2. Percentage of Construction Sites by Acre Size Category

Construction Acreage	Construction Type					
	Residential Detached Homes (%)	Residential Attached Homes (%)	Commercial (%)	Industrial (%)	Institutional (%)	Park and Recreational (%)
> 0 to < 0.5 acres	1.39	8.04	10.68	16.17	12.26	15.46
0.5 to 1 acre	0.83	7.00	17.44	12.50	13.55	5.15
1 to 2 acres	2.07	10.49	24.32	16.17	17.74	13.40
2 to 3 acres	2.04	6.29	12.26	9.56	10.97	6.19
3 to 4 acres	3.24	7.34	6.55	9.56	7.42	4.12
4 to 5 acres	4.87	10.84	5.07	5.15	5.81	7.22
5 to 10 acres	21.40	19.58	10.44	16.18	15.60	21.88
> 10 acres	64.16	30.42	13.24	14.71	16.66	26.57
Total	**100**	**100**	**100**	**100**	**100**	**100**

Note: The percentages are based on the number of building permits for the commercial, industrial, institutional, and parks and recreational columns in Exhibit B–2–1, the number of developments column for other family homes, and the number of units column for single-family homes.

Exhibit B–2–3. Construction Starts by State and Acreage with Starts in States with Equivalent Erosion and Sediment Control Programs Removed

	1–2 acres	2–3 acres	3–4 acres	4–5 acres	Total (1–5 acre sites)
Alabama	908	480	322	304	2,014
Alaska	25	13	9	8	56
Arizona	1,940	997	727	907	4,570
Arkansas	737	392	273	275	1,678
California	6,669	3,368	2,269	2,722	15,028
Colorado	1,153	623	443	409	2,628
Connecticut	0	0	0	0	0
DC	0	0	0	0	0
Delaware	0	0	0	0	0
Florida	0	0	0	0	0
Georgia	2,684	0	0	0	2,684
Hawaii	563	282	190	243	1,279
Idaho	688	363	248	242	1,541
Illinois	3,005	1,565	1,044	1,035	6,649
Indiana	2,603	1,349	854	793	5,598
Iowa	1,109	575	367	341	2,392
Kansas	963	502	322	300	2,087
Kentucky	908	483	334	315	2,040
Louisiana	1,023	530	336	323	2,213
Maine	871	443	259	233	1,806
Maryland	0	0	0	0	0
Massachusetts	393	197	118	122	829
Michigan	0	0	0	0	0
Minnesota	2,433	1,254	757	650	5,094
Mississippi	732	383	246	226	1,587
Missouri	1,494	785	531	524	3,334
Montana	242	127	83	79	531
Nebraska	889	451	283	300	1,923
Nevada	1,068	549	413	537	2,567
New Hampshire	474	0	0	0	474
New Jersey	0	0	0	0	0
New Mexico	403	215	146	133	898
New York	4,847	2,443	1,519	1,645	10,453
North Carolina	0	0	0	0	0
North Dakota	229	119	77	68	493
Ohio	2,619	1,375	931	924	5,849
Oklahoma	706	367	235	221	1,529

Exhibit B–2–3. Construction Starts by State and Acreage with Starts in States with Equivalent Erosion and Sediment Control Programs Removed *(continued)*

	1–2 acres	2–3 acres	3–4 acres	4–5 acres	Total (1–5 acre sites)
Oregon	1,271	675	470	458	2,874
Pennsylvania	0	0	0	0	0
Puerto Rico	0	0	0	0	0
Rhode Island	0	0	0	0	0
South Carolina	0	0	0	0	0
South Dakota	477	246	149	132	1,004
Tennessee	1,510	799	541	511	3,362
Texas	4,571	2,371	1,601	1,715	10,259
Utah	733	393	279	266	1,671
Vermont	426	217	129	115	888
Virgin Islands	0	0	0	0	0
Virginia	1,370	717	459	412	2,957
Washington	2,034	1,065	745	802	4,646
West Virginia	562	286	0	0	848
Wisconsin	3,082	1,396	0	0	4,478
Wyoming	157	82	52	46	337
Total	58,572	28,477	17,764	18,332	123,145

Exhibit B–2–4 further refines the analysis of construction starts by correlating the total construction starts of each state with the total amount of pollutant loading. By subdividing each state by climatic zones, a relationship can be formed between the pollutant loading of each state and construction starts.

Exhibit B–2–4. Estimate of the Numbers of Phase II Storm Water Construction Starts by State and Climatic Zone

State	Climatic Zone Category	% of State Land Area	Starts 1–5 acres
Alabama	P	25	503
Alabama	N	72	1,450
Alabama	T	3	60
Alaska	W, X, Y	100	56
Arizona	D	100	4,570
Arkansas	N	40	671
Arkansas	P	60	1,007
California	A	12	1,803
California	C	40	6,011
California	D	48	7,213
Colorado	D	8	210

Exhibit B–2–4. Estimate of the Numbers of Phase II Storm Water Construction Starts by State and Climatic Zone *(continued)*

State	Climatic Zone Category	% of State Land Area	Starts 1–5 acres
Colorado	E	58	1,524
Colorado	G	27	710
Colorado	H	7	184
Connecticut	R	100	0
DC	P	100	0
Delaware	T	100	0
Florida	P	19	0
Florida	T	81	0
Georgia	N	10	268
Georgia	P	73	1,959
Georgia	T	17	456
Hawaii	V	100	1,279
Idaho	B	35	539
Idaho	D	12	185
Idaho	E	53	817
Illinois	M	100	6,649
Indiana	M	79	4,423
Indiana	N	21	1,176
Iowa	M	100	2,392
Kansas	H	81	1,690
Kansas	M	19	396
Kentucky	N	91	1,856
Kentucky	P	9	184
Louisiana	P	69	1,527
Louisiana	T	31	686
Maine	R	100	1,806
Maryland	N	41	0
Maryland	P	27	0
Maryland	T	32	0
Massachusetts	R	100	829
Michigan	K	65	0
Michigan	M	35	0
Minnesota	F	10	509
Minnesota	K	56	2,853
Minnesota	M	34	1,732
Mississippi	P	97	1,539
Mississippi	T	3	48

Exhibit B–2–4. Estimate of the Numbers of Phase II Storm Water Construction Starts by State and Climatic Zone *(continued)*

State	Climatic Zone Category	% of State Land Area	Starts 1–5 acres
Missouri	M	47	1,567
Missouri	N	46	1,534
Missouri	P	7	233
Montana	E	66	350
Montana	G	34	180
Nebraska	M	20	385
Nebraska	G	43	827
Nebraska	H	37	712
Nevada	D	100	2,567
New Hampshire	R	100	474
New Jersey	R	100	0
New Mexico	D	57	512
New Mexico	E	14	126
New Mexico	G	29	260
New York	R	100	10,453
North Carolina	N	16	0
North Carolina	P	57	0
North Carolina	T	27	0
North Dakota	G	6	30
North Dakota	F	94	463
Ohio	M	42	2,457
Ohio	N	31	1,813
Ohio	R	27	1,579
Oklahoma	H	68	1,040
Oklahoma	M	8	122
Oklahoma	N	19	290
Oklahoma	P	5	76
Oregon	A	37	1,063
Oregon	B	24	690
Oregon	D	27	776
Oregon	E	12	345
Pennsylvania	N	74	0
Pennsylvania	R	26	0
Puerto Rico	Z	100	0
Rhode Island	R	100	0
South Carolina	P	64	0

Exhibit B–2–4. Estimate of the Numbers of Phase II Storm Water Construction Starts by State and Climatic Zone *(continued)*

State	Climatic Zone Category	% of State Land Area	Starts 1–5 acres
South Carolina	T	36	0
South Dakota	F	35	351
South Dakota	G	50	502
South Dakota	M	15	151
Tennessee	N	76	2,555
Tennessee	P	24	807
Texas	D	11	1,128
Texas	H	44	4,514
Texas	I	27	2,770
Texas	P	11	1,128
Texas	T	7	718
Utah	D	67	1,120
Utah	E	33	552
Vermont	R	100	888
Virgin Islands	Z	100	0
Virginia	N	40	1,183
Virginia	P	46	1,360
Virginia	T	14	414
Washington	A	30	1,394
Washington	B	56	2,602
Washington	E	14	650
West Virginia	N	100	848
Wisconsin	K	63	2,821
Wisconsin	M	37	1,657
Wyoming	D	27	91
Wyoming	E	43	145
Wyoming	G	30	101
Total Starts—1994			123,145
Estimate of Total Starts[1]—1998			129,675
Estimate of Total Starts Adjusted for Phase II Waiver Provision			110,223

[1]Based on data collected from the US Bureau of the Census the annual growth rate for the number of building permits issued from 1980 to 1994 was 1.3%. This growth rate is used to estimate 1998 construction starts from the 1994 baseline. However, EPA recognizes the growth rate for construction starts fluctuates yearly and does not necessarily increase each year.

Appendix B–3

Model Construction Site Plans

Drawing Assumptions

Detailed drawings of the model sites (i.e., site plans) and the assumed BMPs that could be used under the Phase II rule are found in the following pages. In developing the BMP mix for each model site, certain simplifying assumptions were needed. EPA assumed the following would apply to each site:

- The project area will remain completely denuded for six months.
- The site slopes uniformly from north to south.
- No structures, swales, or other drainage features will impede the flow of storm water from the northern part of the site to the southern part.
- No run-on will occur from surrounding areas.
- 25' wide streets are located on the north and east sides of the site.
- A stream flows along the south side of the site.
- A 30' vegetated buffer is maintained between the site and the stream.
- Sediment traps will be designed to a volume of 1,800 cubic feet/acre.
- All BMPs will be properly installed and maintained.
- An existing 4' wide swale runs along the east side between the project site and the street. This assumption was made because erosion and sediment control plans typically need to control runoff to and from various existing drainage structures. Although the site slopes north to south, a designer should assume that a considerable amount of sediment will enter the swale due to the constantly changing drainage patterns of a construction site.

Appendix B–4

Post-Construction Runoff Control Cost Analysis

Overview

This appendix describes the methodology used to estimate BMP installation costs attributable to the Phase II Storm Water rule's post-construction municipal minimum measure. Specifically, the costing exercise estimates the costs associated with constructing BMPs that attempt to maintain predevelopment runoff conditions on post-construction sites. The measure affects sites on which land disturbance is greater than or equal to one acre and that discharge into a regulated MS4. However, sites that disturb more than ten acres are not included in this analysis because the Construction General Permit already imposes post-development storm water control requirements on those sites (63FR 7858) .

In estimating incremental costs attributable to this measure, EPA estimated a per-site BMP cost for 12 model sites of varying size (one, three, five and seven acres) and imperviousness (35%, 65% and 85%). This approach was based on the results of an EPA Office of Science and Technology study (Preliminary Data Summary of Urban Storm Water Best Management Practices, US EPA, Office of Science and Technology, December 1998b). EPA used the Office of Science and Technology study to develop a combination of BMPs for the model sites and calculate costs based on the amount of storm water runoff expected from sites of varying imperviousness. Based on considerations of site size constraints, total BMP costs and terrain variations, EPA calculated a weighted average BMP cost, including operation and maintenance costs, for each of the model sites.

Two additional adjustments refined the per-site cost estimate for post-construction control. First, EPA included a cost reduction associated with nonstructural practices that it anticipates will be used to comply with this measure. EPA identified per-site average cost reductions associated with redirection of rooftop runoff ("rooftop runoff credit"). Second, EPA anticipates ancillary cost savings because the new BMPs (structural and nonstructural) will also reduce peak storm water flows, allowing developers to save on construction costs when they build their sewer connections. The potential cost savings, based on estimates of reduced per-site costs for storm water conveyances, were also subtracted from the initial per-site BMP cost.

The adjusted per-site BMP cost was then multiplied by the total number of construction sites that are located in Phase II urbanized areas to obtain a national cost estimate.

Detailed Description of the Cost Analysis

Phase II Post-Construction Universe

EPA derived the number of construction starts affected by this measure by further refining the construction start analysis used to identify the number of starts that would be regulated under the Phase II construction program for sites nationwide. As a result, this analysis started with the data set that is described in Appendix B–2, steps one through seven. Two additional steps, described below, were performed to identify the post-construction universe.

Step One. EPA used county-level Bureau of the Census construction data as the basis for identifying the universe of construction starts affected by the post-construction minimum measure (construction starts that disturb between one and 10 acres of land and occur in Phase II urbanized areas). EPA identified all counties that are located either entirely or partially inside urbanized areas. EPA eliminated all other nonurbanized counties from the construction start data set. For counties that are located partially inside an urbanized area, EPA assumed that construction activity is evenly distributed and, therefore, based its calculation of the number of construction starts on ratio of county land located in the urbanized area versus outside the urbanized area.

Step Two. EPA removed construction starts that were located in counties with roughly equivalent programs under CZARA in the following states: Rhode Island, Delaware, Maryland, Pennsylvania, Florida, South Carolina and Alaska. Exhibit B–4–1 summarizes the number of construction starts by acreage category that may be affected by the Phase II rule.

Exhibit B–4–1. Estimated Number of Construction Starts Potentially Affected by the Phase II Post-Construction Runoff Control Provision

Construction Starts (1998)				
Area Acreage	**Multi-Family Residential (35%)**	**Multi-Family/ Commercial/ Institutional (65%)**	**Commercial (85%)**	**Totals**
1 Acre	221	2,942	2,505	5,668
3 Acres	287	2,451	1,939	4,677
5 Acres	228	822	523	1,573
7 Acres	244	818	384	1,445
Totals	981	7,033	5,351	13,364

Per-Site Costs

Step One. EPA developed a theoretical series of representative sites to which typical best management practices could be applied. The 12 model sites varied by site size (one, three, five and seven acres) and level of imperviousness (35%, 65% and 85%). Imperviousness levels for multi-family and commercial development were established based on a review of local government reports detailing average imperviousness by land use type (see Exhibit B–4–2). To account for ranges of imperviousness reported for multi-family (35%–65%) and commercial (65%–85%) development, EPA assigned half the starts to either impervious category. For example, of the 442 multi-family one-acre starts, 221 are counted in the 35% impervious category while the other 221 are counted in the 65% impervious category. All institutional starts are counted in the 65% impervious category, reflecting the reported impervious range of 50-80%.

Exhibit B–4–2. A Summary of Impervious Surface Percentages for Commercial and Multi-Family Land Use

Reference	% Impervious
Commercial	
US Soil Conservation Service. 1975. Technical Release 55. Urban Hydrology for Small Watersheds	85
MWCOG. 1987. Controlling Urban Runoff: A Practical Manual for Planing and Designing Urban BMPs	60–80 (light com) 80–100 (heavy com)
MWCOG. 1997. Anacostia Watershed Study— draft (survey of land use and corresponding impervious surface levels in the District of Columbia, Montgomery and Prince Georges counties)	50–70(low density com) 70–80(medium density com) 80–90(med/high density com) 90–100(high density com)
Maryland Department of the Environment (Jim George and Greg Lindsey). 1991. Financing Stormwater Controls in Carroll County: A Preliminary Investigation	82

Exhibit B–4–2. A Summary of Impervious Surface Percentages for Commercial and Multi-Family Land Use

Reference	% Impervious
Commercial	
NVPDC. 1990. Evaluation of Regional BMPs in the Occoquan Watershed	90–95 (suburban shopping center/cbd)
Institutional	
MWCOG. 1997. Anacostia Watershed Study—draft (survey of land use and corresponding impervious surface levels in the District of Columbia, Montgomery and Prince Georges counties)	50–70 (schools, military installations, churches) 70–80 (schools, colleges, churches)
Multi-Family	
US Soil Conservation Service. 1975. Technical Release 55. Urban Hydrology for Small Watersheds	38 (lots $\leq$ 1/8 acre) 65 (lots 1/4 acre)
MWCOG. 1987. Controlling Urban Runoff: A Practical Manual for Planing and Designing Urban BMPs	35–60 (townhouse/garden apts)
Maryland Department of the Environment (Jim George and Greg Lindsey). 1991. Financing Stormwater Controls in Carroll County: A Preliminary Investigation	40–68 (garden apts/condos)
City of Olympia. 1994. Impervious Surface Reduction Study	42–56 (4–7 units/acre)
MWCOG. 1997. Anacostia Watershed Study—draft (survey of land use and corresponding impervious surface levels in the District of Columbia, Montgomery and Prince Georges counties)	30–50(row houses/garden apts) 50–70(mid-rise apt/multi-unit) 70–80(high density res)
NVPDC. 1990. Evaluation of Regional BMPs in the Occoquan Watershed	35–75(6–30 DU/Acre)

For purposes of this analysis, EPA assumed that single family residential development would be able to meet the post-construction runoff control program goal using storm water sensitive site design. Therefore, single family residential construction starts were excluded from this analysis. The Multi-Sector General Permit places post-development runoff requirements on industrial sites that are similar to the Phase II requirements for the post-construction runoff control minimum measure and, as a result, these were also excluded from this analysis (60 FR 50804).

Step Two. EPA identified five best management practices (BMPs) that developers could use to meet the municipal program requirements of the new development/redevelopment minimum measure. The following five BMPs selected for the analysis represent typical water quality BMPs: dry detention pond, infiltration trench, infiltration basin, grass swales and sand filter. EPA accounted for site constraints resulting from site size and impervious level when assigning BMPs to the model sites, then developed an average per-site BMP cost. This per-site cost was adjusted to account for potential cost reductions associated with the redirection of rooftop runoff.

BMP Installation and Maintenance Costs. Per-site costs were calculated based on estimates of water quality volume (WQv), which is the volume of water that a BMP is designed to treat.[1] Using Schueler's simple method, EPA determined water quality volume for the one-inch storm as follows (US EPA, 1998):

WQv = (.05 + .9I) A/12

where:WQv = Water Quality Volume (Acre-Feet)
I=Impervious Fraction in the Watershed
A=Watershed Area (Acres)

Exhibit B–4–3 summarizes the results of calculations determining water quality volume for each of the twelve model sites described above. Total volume, which includes both water quality volume and detention volume, is not used in this analysis because EPA assumed that site operators will account for detention volume where it is needed to correct for flooding hazards; the control of detention volume is not a feature of the Phase II Rule. Construction and maintenance costs depend on the size of the BMP, which depends on the water quality volume.

Exhibit B–4–3. Water Quality Volume Calculations for Twelve Model Sites

Square Acreage (A)	**1 Acre**			**3 Acres**		
Percent Impervious Cover (I)	**35**	**65**	**85**	**35**	**65**	**85**
Water Quality Volume (acre-feet) (P)(Rv)(A/12) P = 1" of rainfall Rv = 0.05 + 0.9 (I) A = Drainage Acreage	0.03	0.04	0.07	0.08	0.12	0.20
Square Acreage (A)	**5 Acres**			**7 Acres**		
Percent Impervious Cover (I)	**35**	**65**	**85**	**35**	**65**	**85**
Water Quality Volume (P)(Rv)(A/12) P = 1" of rainfall Rv = 0.05 + 0.9 (I) A = Drainage Area	0.13	0.18	0.34	0.18	0.26	0.48

EPA's cost analysis used the construction cost equations and the annual maintenance cost assumptions in *Preliminary Data Summary of Best Management Practice Cost Analysis* (EPA, 1998), which reports the findings of OST's national review of capital costs attributable to BMP design and construction. Exhibit B–4–4 summarizes construction cost equations and maintenance costs for each of the five BMPs.

[1] For example, a BMP may be designed to capture the first inch of runoff from the drainage area. Any volume of rainfall over the first inch would bypass the BMP. Therefore, water quality volume for this BMP would be one watershed inch.

Exhibit B–4–4. Descriptions of New Development and Redevelopment BMPs

BMP	Construction Cost Equation	Maintenance Costs[1]	Notes	Sources
Detention Pond	$18.5WQv^{0.70}$	5%	Ponds are a reliable best management practice.	a,b,c,d,e
Infiltration Trench	1–3ac: 4,400 5 ac: 10,400 7 ac: 3.9 WQv + 2,900	12%	Although infiltration trenches are designed to last a long time, they need to be inspected and rebuilt if they become clogged.	d,e,f
Infiltration Basin	1.3 WQv	4%	Infiltration basins are not very reliable, and tend to become clogged.	g
Swale	(15%)*(%Impervious area)*(.25$/sf)	5%	Used for smaller development, requires frequent maintenance in order to function long-term.	d
Sand Filter	4 WQv	12%	Sand filters require frequent maintenance in order to function long-term.	a,e,g

Notes:
WQv = Water Quality Volume
Sand filter volume was estimated at 4WQv, which is slightly high, to account for the relatively small drainage area.
Life = Length of time without major modifications or reconstruction

a = Brown and Schueler, 1997b
b = Wiegand, et al, 1986
c = Schueler, 1987
d = SWRPC, 1991
e = US EPA, 1993a
f = Schueler, 1997
g = Livingston, et al, 1997

[1] Presented as % of construction costs on an annual basis

As noted previously, this costing analysis utilizes a theoretical set of representative sites to which typical best management practices are assigned. For each of these representative sites, Exhibit B–4–5 shows which BMPs were used to develop an average per-site cost. Some BMPs are more likely to be used than others for different sizes of sites and different degrees of imperviousness. The selection of BMPs to use for each site was based on the following assumptions:

- To allow for variety in sites and to provide a range, a selection of three BMPs was typically provided.
- Engineers will use the most cost effective BMP provided site restrictions are not a factor.
- It is standard practice and feasible to select detention basins in the design of BMPs. Consequently, a detention basin was assigned to each of the model sites.

- Infiltration trenches are not cost effective on smaller sites with low impervious levels but may be on larger sites.

- In general, swales are used and effective on small sites with low impervious levels. Due to cost constraints, sand filters are typically used on larger sites.

Exhibit B–4–5. BMPs Used for Cost Analysis

Site Size (acres)	% Impervious	Percent Selected for BMP Design				
		Detention Basin	Infiltration Trench	Infiltration Basin	Swale	Sand Filter
1	35	40		40	20	
	65	30	30	30	10	
	85	40	40			20
3	35	40		40	20	
	65	33.3	33.3	33.3		
	85	33.3	33.3	33.3		
5	35	40		40	20	
	65	50		50		
	85	30	30	30		10
7	35	40	10	40		10
	65	45		45		10
	85	66.6				33.3

Exhibit B–4–5 also shows the weights that were assigned to each BMP to obtain a weighted average cost for each type of site. Nonuniform weights were provided when one BMP was believed to be less likely to be selected than the others. The sand filter and swale BMPs were given less weight than the other possible options to account for site constraints or limited effectiveness. The remaining weight was then distributed evenly among the other BMPs. For example, on a five-acre site with 85% impervious surface, the cost of a sand filter exceeds the combined average cost of the detention pond, infiltration trench, and infiltration basin. Because an engineer would be more likely to select the most cost effective BMP or combination of BMPs, and sand filters are used only when site constraints present no other option, EPA assigned a low weight to the sand filter (10%) and equal weights to the remaining three BMPs (30% each). By assigning nonuniform weights to the BMPs, the analysis more accurately reflects expected costs under actual development conditions.

The BMP costs shown in Exhibit B–4–6 are capital costs associated with each BMP for each size site and impervious cover. Exhibit B–4–6 does not report costs for BMPs that were not selected for a model site because of limitations related to site size and imperviousness The average weighted cost was obtained by using the weights in Exhibit B–4–5. The total cost is the sum of the average weighted BMP and operating and maintenance (O&M) costs.

The O&M costs shown in the exhibit are present value calculations of O&M costs over ten years (i.e., two NPDES permit periods) assuming a 7% discount rate. These capitalized O&M costs are included in the cost analysis because they represent the social costs of maintaining the effectiveness of the structural BMPs installed in any year. If the BMPs were not maintained, their effectiveness would decline and the overall effectiveness of this provision of the rule would decline.

Exhibit B–4–6. Average BMP Installation Costs and O&M Costs for Model Sites

BMP	**Construction Costs ($) [1,2,3]**											
Acreage	**1 Acre**						**3 Acres**					
	35		**65**		**85**		**35**		**65**		**85**	
Percent Impervious Cover	**BMP Cost**	**O&M Cost**	**BMP Cost**	**O&M Cost**	**BMP Cost**	**O&M Cost**	**BMP Cost**	**O&M Cost**	**BMP Cost**	**O& M Cost**	**BMP Cost**	**O&M Cost**
Detention Pond	2,535	127	3,472	174	5,083	254	5,470	274	7,483	374	10,599	530
Infiltration Trench	—	—	4,400	528	4,400	528	—	—	10,400	1,248	10,400	1,248
Infiltration Basin	1,468	59	2,300	92	—	—	4,403	176	6,889	276	11,326	453
Swale	572	29	1,062	53	—	—	1,715	86	—	—	—	—
Sand Filter	—	—	—	—	12,197	1,464	—	—	—	—	—	--
Avg. Weighted Cost ($)	**1,716**	**561**	**3,158**	**1,710**	**6,232**	**4,253**	**4,292**	**1,384**	**8,257**	**4,443**	**10,775**	**5,223**
Total Cost ($)	**2,277**		**4,867**		**10,486**		**5,676**		**12,700**		**15,998**	

Exhibit B–4–6. Average BMP Construction Costs and O&M Costs for Model Sites *(continued)*

BMP	**Construction Costs ($)** [1,2]											
Acreage	**5 Acres**						**7 Acres**					
Percent Impervious Cover	**35**		**65**		**85**		**35**		**65**		**85**	
	BMP Cost	**O&M Cost**	**BMP Cost**	**O&M Cost**	**BMP Cost**	**O&M Cost**	**BMP Cost**	**O&M Cost**	**BMP Cost**	**O&M Cost**	**BMP Cost**	**O&M Cost**
Detention Pond	7,822	391	9,994	500	15,366	768	9,899	495	12,735	637	19,561	978
Infiltration Trench	—	—	10,400	1,248	10,400	1,248	33,720	4,046	—	—	—	—
Infiltration Basin	7,338	1,248	10,411	417	19,254	770	10,273	411	14,723	589	—	—
Swale	2,859	294	—	—	—	—	—	—	—	—	—	—
Sand Filter	—	—	—	—	59,242	7,109	31,610	3,793	45,300	5,436	83,635	10,036
Avg. Weighted Cost ($)	**6,636**	**2,124**	**10,269**	**5,067**	**13,506**	**5,871**	**11,441**	**5,387**	**20,220**	**11,228**	**40,919**	**28,076**
Total Cost	**8,760**		**15,336**		**19,377**		**16,828**		**31,448**		**68,996**	

Note: Costs are for construction and operation and maintenance costs.
[1]Refer to Exhibit B–4–4 for BMP construction cost equations and Exhibit B–4–3 for volumes used to calculate construction costs.
[2]Refer to Exhibit B–4–5 for weighted BMP information.
[3]Dollar costs provided in this exhibit are not intended to imply this degree of precision. Numbers can be rounded to the nearest 100.

Rooftop Runoff Credit. EPA anticipates that non-structural practices will be used whenever feasible to comply with this measure, because they are generally less costly to implement than structural measures. One simple design practice, the redirection of rooftop runoff from impervious surfaces to grassy areas, can be used as a way to reduce the need for installation of structural BMPs. In EPA's cost analysis, per-site average cost reductions associated with redirection of rooftop runoff have been calculated and subtracted from BMP installation and maintenance costs.

The steps used in calculating the rooftop runoff credit are as follows:

Multi-family sites: The calculations are based on an average density for townhouses of 10 townhouses (TH) per acre. It was assumed that the average square footage of the rooftop was 800sq. For example, to calculate a reduced impervious area for three-acre 65% multi-family sites, the following steps are used:
- 3 acre x 10TH/acre = 30TH
- 30TH x 800 sq/TH = 24,000 sq = 0.55 acre (total rooftop area of townhouse)
- 3 acre x 65% = 1.95 acre (total impervious area on site)
- 1.95 acre–0.55 acre = 1.4 acre
- 1.4 acre/3 acre = 46% rounded to 50%

Commercial/Institutional sites: Floor Area Ratio (FAR) was used to determine rooftop surface area. FAR for commercial sites ranges from 0.25–0.5. For the one–three acre sites a FAR of 0.25 was used, and for the five–seven acre sites, a FAR of 0.35 was used. It was also assumed for these calculations, a single story building, and the discharge from the roof tops will be from multiple locations along the roof. For example, to calculate a reduced impervious area for three-acre 65% commercial sites, the following steps are used:
- 3 acre x 65% = 1.95 acre (total impervious area on site)
- 3 acre x 65% x 0.25 = 0.48 acre (area of rooftop on impervious surface)
- 1.95 acre–0.48 acre =1.47 acre
- 1.47 acre/3 acre = 49% rounded to 50% (revised impervious surface area)

Results are presented in Exhibit B–4–7.

Exhibit B–4–7. Cost Reductions from Redirection of Rooftop Runoff

Average Per-Site Reduction in BMP Costs (1998 dollars)			
Area (Acreage)	**35% Impervious (Multi-Family Residential)**	**65% Impervious (Multi-Family/Commercial /Institutional)**	**85% Impervious (Commercial)**
1 Acre	$266	$425	$0
3 Acres	$674	$1,643	$0
5 Acres	$1,048	$3,058	$0
7 Acres	$2,301	$12,097	$0

Weighted Average Per-Site Costs. After incorporating the rooftop runoff credit, Exhibit B–4–8 summarizes the weighted average total per-site costs for each of the modeled sites.

Exhibit B–4–8. Summary of Per-Site Average Total Costs by Acreage and by Percent Imperviousness

Average BMP Costs (1998 dollars)			
Area (Acreage)	**35% Impervious (Multi-Family Residential)**	**65% Impervious (Multi-Family/Commercial /Institutional)**	**85% Impervious (Commercial)**
1 Acre	$2,277	$4,867	$10,486
3 Acres	$5,676	$12,698	$15,998
5 Acres	$8,760	$15,353	$19,377
7 Acres	$16,828	$31,448	$68,996

Associated Cost Savings

An ancillary benefit of the post-construction runoff provision is that the new BMPs (structural and nonstructural) will also reduce peak storm water flows that enter the storm sewer system. Consequently, developers may be able to save on construction costs when they build their sewer connections. EPA selected the option that is most closely aligned with the cost analysis, which assumes that all of the construction sites install structural BMPs that can detain water quality volume on site long enough to reduce contaminant concentrations. In effect, the BMPs in the cost analysis reduce the peak runoff that must be handled by conventional storm water conveyances. Consequently, there is an implied potential for developers to reduce the cost of these conveyances. This is the basis for the following cost-savings analysis.

The analysis assumed that reductions in peak runoff volumes generate cost savings associated with using smaller diameter pipe compared to pipe sizes that might be required without the BMPs. In the analysis, the size of pipe that would be required to transport the water quality volume with and without the use of the storm water BMP was determined for each of the twelve model sites used in the cost analysis (i.e., four acreage sizes and three impervious surface percentages). The second and third columns in Exhibit B–4–9 show the water quality volumes for the one-inch and five-inch storm events, respectively.

The standard approach for calculating the size of pipe used in a storm water/sewer drainage system is to determine the peak discharge from a given property and then use the value in Mannings equation to determine the pipe diameter. In these calculations, a water quality volume was converted to a peak discharge using Claytor and Schueler's method (1996) (columns 4 and 5 in Exhibit B–4–9) for the five-inch storm (water quality volume without a BMP) and the one-inch storm (water quality volume retained by BMP). Then, Mannings equation was used to calculate the pipe diameter required to transport runoff with the use of a BMP measure (five-inch storm minus the one-inch storm) and without a BMP measure (five-inch storm). The resulting reduction in pipe diameter was assumed to represent the size by which the storm water/sewer drainage piping could be reduced because of the implementation of the BMP (column 6 in Exhibit B–4–9).

Exhibit B–4–9. Summary of Cost Savings for Smaller Storm Water Runoff Conveyance Systems (1998 dollars)

Site	WQ Volume (acre-ft)[1]		Discharge (cfs)[2]		Reduction In Pipe Diameter (inches)[3]	Reduction In Pipe Cost ($/LF)	Linear Feet (ft)	Per-Site Cost Savings ($)	Construction Starts[4]	National Cost Savings ($)
	1”	5”	1”	5”						
1 acre										
35%	0.03	0.15	0.45	2.28	1	0	210	0	221	0
65%	0.05	0.26	0.80	4.22	1	0	210	0	2,492	0
85%	0.07	0.34	1.18	5.73	2	1.40	210	294	2,505	736,470
3 acres										
35%	0.09	0.46	1.18	5.99	1	1.40	360	504	287	144,900
65%	0.16	0.79	2.22	11.01	2	1.75	360	630	2,451	1,543,815
85%	0.20	1.02	3.00	15.28	1	2.05	360	738	1,939	1,430,982
5 acres										
35%	0.150	0.76	1.69	8.55	1	0	470	0	228	0
65%	0.26	1.32	3.17	16.12	2	2.05	470	964	822	792,479
85%	0.34	1.70	4.46	22.29	2	4.00	470	1,880	526	983,240
7 acres										
35%	0.21	1.06	2.13	10.78	2	1.75	550	963	244	234,369
65%	0.37	1.85	4.02	20.14	2	4.00	550	2,200	818	1,798,500
85%	0.48	2.38	5.40	26.74	2	0	550	0	384	0
Total										**7,664,755**

Notes:

[1]The water quality (WQ) volume used for each type and size of property was obtained from Appendix B–4, which used Schueler's simple method for the one-inch storm event as reported in acre-feet.

[2]The peak discharge was determined by converting the water quality volume using Claytor and Schueler's method (1996).

[3]The diameter of pipe capable of carrying the discharge calculated for the five-inch storm event and the 5-inch minus the 1-inch storm event was determined using the Manning equation ($D = [(2.16Qn)/S_o^{1/2}]^{3/8}$) with a Mannings n value of 0.015 for concrete, a slope (S) of 1%, and a discharge (Q) as determined in column 4 and 5. This pipe diameter was then converted to inches and rounded up to the next commercially available pipe size.

[4]The number of construction starts for multi-family residential (35% impervious), multi-family, commercial and institutional (65% impervious), and commercial (85% impervious) starts are from Exhibit B–4–1.

The cost savings were estimated by subtracting the unit cost of the pipe size required to transport the five-inch storm volume from the unit cost of the pipe size required to transport the five-inch storm minus the one-inch storm volume. The 1999 Means manual was used to determine the material cost per linear foot assuming the pipe was made of concrete (non-reinforced pipe, extra strength, B&S or T&G joints). The cost-savings analysis used standard pipe sizes; therefore, if the reduction in the pipe size was not sufficient to drop to the next smaller standard pipe diameter (i.e., 27-inch pipe to a 24-inch pipe), a zero cost savings was assumed. Also, the cost-savings analysis did not assume any cost savings associated with construction or maintenance activities.

Because costs are measured in dollars per linear foot, EPA needed an estimate of approximate average length of storm water drain pipe adjacent to each construction start. To calculate the pipe length, EPA assumed that the one-, three-, five- and seven-acre properties are square in shape and that the storm water drain runs along one side of the property. Therefore, the total length of piping per property was determined by taking the square root of the acreage area and converting from acres to feet (column 8 in Exhibit B–4–9).

EPA calculated cost savings per model site by multiplying three values: the cost savings per linear foot, the linear feet per site, and the number of sites. Column 9 in Exhibit B–4–9 shows the number of construction starts used to estimate BMP costs, and column 10 reports aggregate cost savings per type of model site. Total annual cost savings across all sites was estimated to be $7.7 million.[2]

National Costs

Total per-site costs (Exhibit B–4–8), less the cost savings (Exhibit B–4–9), were multiplied by the number of construction starts summarized in Exhibit B–4–1 to obtain total national costs which are shown in Exhibit B–4–10. Total estimated post-construction runoff control costs are approximately $178 million per year.

[2]EPA assumes that because BMP costs are incurred at all sites, all sites could potentially reduce storm water drain costs. This may overestimate the potential cost savings if some of the construction sites that install BMPs are not able to reduce their subsurface storm water costs. The bias introduced by the linear footage assumption is uncertain. It may tend to overestimate average storm sewer lengths for smaller developments, but underestimate average lengths for larger developments. Nevertheless, it is important to realize that this analysis includes only one type of cost savings. If the rule encourages developers to implement design strategies such as clustering, or if the rule encourages flexibility in building requirements such as street widths or parking lot sizes, the construction cost savings are potentially large.

Exhibit B–4–10. Estimated Post-Construction Runoff Control Costs

Area	35% Impervious (Multi-Family Residential)	65% Impervious (Multi-Family/ Commercial/ Institutional)	85% Impervious (Commercial)	Total Cost (1998 dollars)
1 Acre	$503,163	$14,318,035	$25,530,478	$40,351,676
3 Acres	$1,486,961	$29,571,535	$29,588,931	$60,647,426
5 Acres	$2,001,641	$11,835,630	$9,151,038	$22,988,309
7 Acres	$3,863,272	$23,910,571	$26,494,414	$54,268,258
Total Cost	$7,855,037	$79,635,771	$90,764,861	$178,255,669

This approach to estimating costs on a per-site basis implicitly assumes that this measure is implemented by installing structural BMPs on a site-by-site basis. It is important to note, however, that the Phase II Storm Water rule allows flexibility in how MS4s design and implement their post construction runoff control programs. Consequently, some programs may adopt alternative approaches such as implementing a watershed management strategy, which may be more cost effective than site-by-site BMPs. Furthermore, developers may also have flexibility in whether they implement structural or nonstructural BMPs. These types of flexibility cannot be readily be incorporated in the cost analysis, and as a result the analysis may represent the higher end of the potential cost range.

Appendix B–5

Federal and State Cost Analysis and Assumptions

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Federal and State Cost Analysis and Assumptions

Promulgation of the Phase II rule will expand the universe of municipalities and construction activities required to submit an application for a National Pollutant Discharge Elimination System (NPDES) storm water permit. The Phase II rule has the potential to increase the universe of municipalities by a total of 5,106 places/counties and to require permitting authorities to process permit applications from approximately 110,223 construction sites and 19,452 waivers each year. The annual cost to the Federal government is estimated to be approximately $457,000 and the annual cost to State governments is estimated to be approximately $4,861,000.

B.5.1 Federal Costs

Once the Phase II rule is implemented, EPA will be required to operate the NPDES program in non-NPDES authorized states.[3] Environmental Protection Agency (EPA) will be responsible for two types of costs: start-up costs and annual costs. The start-up costs include the incorporation of Clean Water Act 401 certification language into the general permit that EPA anticipates developing for small MS4s, the review and filing of non-NPDES-authorized States/Territories plans, development of storm water goals for these states and territories, and the designation of additional . All the start-up costs associated with the administration of Phase II will occur once as the rule becomes implemented. Some of these start-up costs may also be incurred periodically as needed at the beginning of each new permit cycle. For example, the incorporation of 401 certification language into the general permit language is likely to only need to be done once, while the designation of additional MS4s may occur occasionally at the beginning of each new permit cycle.

When the Federal government is the permitting authority for the Phase II municipalities, EPA will be required to annually process the applications, review plans, issue NPDES storm water permits to the municipal applicants, and review and file any reports. For construction sites disturbing between one and five acres of land in non-NPDES authorized States, EPA will be required to process the notices of intent (NOIs) to be covered by the construction general permit, the notices of termination (NOTs), and the waiver certification. For small MS4s, EPA will be required to process and review the NOI and report. Exhibit B–5–1 provides the estimated start-up costs and Exhibit B–5–2 presents the annual costs to the Federal government.

[3]The non-NPDES authorized States and territories include Alaska, Arizona, District of Columbia, Idaho, Maine, Massachusetts, New Hampshire, New Mexico, Puerto Rico. While Florida and Texas will not administer the storm water portion of the NPDES program until the year 2000, they are counted as part of the NPDES authorized states and territories since the Rule will take effect in 2003.

Exhibit B–5–1. Estimated Federal Start-Up Costs (1998 dollars)

Phase II Program Element	Respondents Per Year[1]	Burden Hours per Respondent[2]	Hourly Labor Costs[3]	Estimated Cost[4]	Annual Cost Over Permit Period[5]
Review and File Modified State Programs	9	12	$28.37	$3,064	$613
Develop Storm Water Goals in Non-Authorized States	9	100	$28.37	$25,533	$5,107
Incorporate 401 Certification Language	9	5	$28.37	$1,277	$255
Designation of Additional MS4s	9	66.6	$28.37	$17,005	$3,401
TOTAL COSTS[6] $46,879					$9,376

[1] The number of respondents, 9, represents the non-NDPES states and territories that EPA will operate the NPDES program for.
[2] Burden hours per respondent were estimated by EPA.
[3] Hourly labor costs are based upon an average annual Federal employee salary of $39,338, divided by 2,080 labor hours per year and then increased 50% to represent overhead costs (US Office of Personnel Management, 1998).
[4] Estimated cost is the product of the respondents per year, hours per respondent, and hourly labor costs.
[5] To determine annual costs over permit period, estimated cost is divided by five years.
[6] Numbers may not total due to rounding.

Exhibit B–5–2. Estimated Federal Annual Costs (1998 dollars)

Phase II Program Activity	Respondents Per Year[1]	Burden Hours per Respondent[2]	Hourly Labor Costs[3]	Estimated Cost[4]
Construction Program				
Waiver Cert. Processing & Review	1,607	1	$28.37	$45,590
NOI Processing & Review	9,104	1	$28.37	$258,280
NOT Processing	9,104	0.5	$28.37	$129,140
Small MS4 Program				
NOI Processing & Review	357	0.8	$28.37	$8,102
Report Processing & Review	357	1.6	$28.37	$16,205
Annual Total[5]				$457,318

[1] The number of respondents per year was based on the 1990 Bureau of Census data for small MS4s and 8.26% of total starts that are in non-NPDES states and territories in Exhibits B–2–3 and B–2–4 for construction.
[2] Burden hours per respondent were estimated by EPA.
[3] Hourly labor costs are based upon an average annual Federal employee salary of $39,338, divided by 2,080 labor hours per year and then increased 50% to represent overhead costs (US Office of Personnel Management, 1998).
[4] Estimated cost is the product of the respondents per year, hours per respondent, and hourly labor costs.
[5] Numbers may not total due to rounding.

B.5.2 State Costs

States and Territories that are authorized to operate the NPDES program will experience both start-up costs and annual costs.[4] The start-up costs include the costs associated with revising each NPDES authorized State's procedures, as described by 40 CFR 123.62(b), the incorporation of Clean Water Act 401 certification language into the general permit, and designation of

[4] There are 44 States and Territories authorized to operate the NPDES program. No Native American Tribes currently have NPDES authorization.

additional MS4s. The annual cost includes the State's responsibility as the permitting authority. For the Phase II municipal program, States will be required to will be required to annually process the applications, review plans, issue NPDES storm water permits to the municipal applicants, and review and file any reports. For construction sites disturbing between one and five acres of land, the States will be required to process the NOIs, NOTs, and waiver certification form. For small MS4s, States will be required to process and review the NOI and report. Exhibit B–5–3 provides the estimated start-up costs and Exhibit B–5–4 presents the annual costs to the State government.

Exhibit B–5–3. Estimated State Start-up Costs (1998 dollars)

Phase II Program Element	Respondents Per Year[1]	Burden Hours per Respondent[2]	Hourly Labor Costs[3]	Estimated Cost[4]	Annual Cost Over Permit Period[5]
401 Certification	44	12	$26.87	$14,187	$2,837
State Revision Procedures[6]	44	100	$26.87	$118,228	$23,645
Designation of Additional MS4s	44	66.6	$26.87	$78,739	$15,748
TOTAL COSTS[7]				$211,154	$42,230

[1] The number of respondents represents the 44 NPDES-Authorized States and Territories.
[2] Burden hours per respondent were estimated by EPA.
[3] The hourly labor rate for NPDES Authorized States and Territories was based on the average hourly rate for state and municipal employees as determined by the US Department of Labor, Bureau of Labor Statistics, Employment Cost Indexes and Levels, 1975–1995, Bulletin 2466.
[4] Estimated cost is the product of the respondents per year, hours per respondent, and hourly labor costs.
[5] To determine annual costs over permit period, estimated cost is divided by five years.
[6] 40 CFR 123.62(b).
[7] Numbers may not total due to rounding.

Exhibit B–5–4. Estimated State Annual Costs (1998 dollars)

Phase II Program Element	Respondents Per Year[1]	Burden Hours per Respondent[2]	Hourly Labor Costs[3]	Estimated Cost[4]
Construction Program				
Waiver Cert. Processing & Review	17,845	1	$26.87	$479,495
NOI Processing & Review	101,119	1	$26.87	$2,717,068
NOT Processing	101,119	0.5	$26.87	$1,358,534
Small MS4 Program				
NOI Processing & Review	4,749	0.8	$26.87	$102,085
Report Processing & Review	4,749	1.6	$26.87	$204,169
Annual Total[5]				$4,861,350

[1] The number of respondents per year was based on the 1990 Bureau of Census data for small MS4s and 91.7% of total starts that are in NPDES states and territories in Exhibits B-2-3 and B-2-4 for construction.
[2] Burden hours per respondent were estimated by EPA.
[3] The hourly labor rate for NPDES Authorized States and Territories was based on the average hourly rate for state and municipal employees as determined by the US Department of Labor, Bureau of Labor Statistics, Employment Cost Indexes and Levels, 1975-1995, Bulletin 2466.
[4] Estimated cost is the product of the respondents per year, hours per respondent, and hourly labor costs.
[5] Numbers may not total due to rounding.